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Black Oak Decline on New York's Long Island 1990–1996

Abstract

Decline of black oak (*Quercus velutina* Lamarck) on New York's Long Island in the early 1990's was associated with a cynipid gall wasp and a fungal twig canker. Symptoms included swollen twigs, gnarled branches, fungal cankers, and crown dieback. A study conducted from 1994 to 1996 showed that symptoms occurred in residential areas, managed parks, and forested areas, in all sizes and ages of black oak. The severity of decline varied greatly across Long Island. The fact that unaffected oaks were found next to declining oaks suggests that microsite characteristics may have contributed to the decline. Trees with high vigor that grew more rapidly prior to the gall wasp outbreak, however, suffered less dieback than those that grew more slowly prior to the outbreak. A series of periodic environmental stress factors, such as drought and defoliation, probably played an important role in triggering susceptibility and decline in affected trees. Future cycles of decline lasting 5–10 years are expected, but cannot be predicted. Management of this decline syndrome is best accomplished by maintaining tree health before and during periods of stress, and removing affected trees that pose a threat to human lives and property. No specific control tactics are known.

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Black Oak Decline on New York's Long Island, 1990–1996

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Introduction

In the early 1990's, residents and arborists on New York's Long Island began reporting the deteriorating health of black oak (*Quercus velutina* Lamarck). Symptoms included swollen twigs, gnarled branches, fungal twig cankers, tip dieback, thinning crowns, leaf galls, unusually large leaves, and epicormic branches (figure 1). Initial investigations were conducted by Suffolk County and Cornell Cooperative Extension, the New York State Department of Environmental Conservation, and members of the Long Island Arboricultural Association. With the assistance of Cornell University, two organisms closely associated with the decline were identified: a gall wasp (*Bassettia ceropteroides*) belonging to the family Cynipidae (cynipid), and a fungal twig canker (*Botryosphaeria* sp.). Little else was known about the biology, ecology, and management of this decline syndrome.

A formal study of this syndrome was initiated in 1994. This paper describes the two organisms closely related with the decline and summarizes the study's findings and recommendations for management.

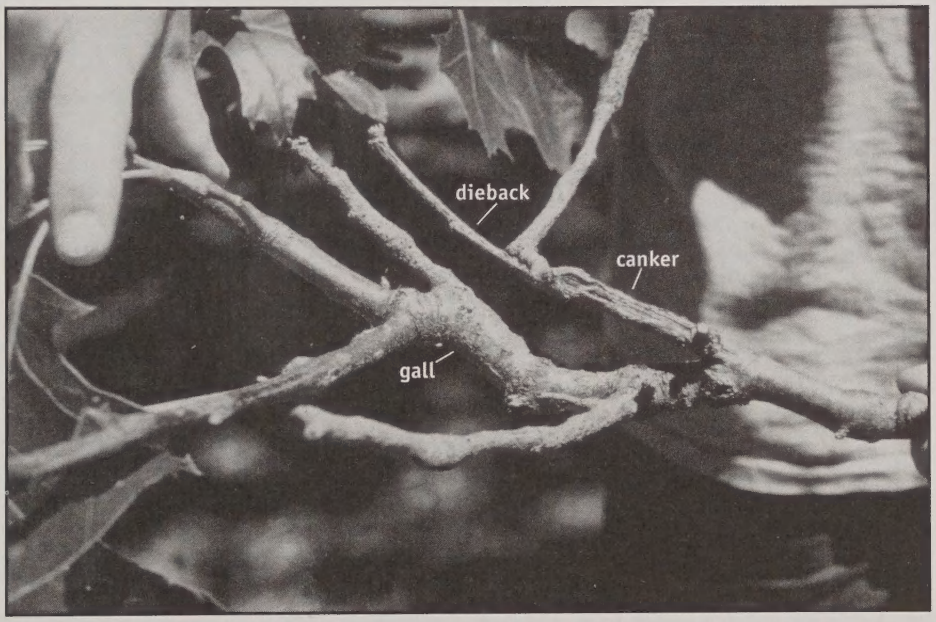

Figure 1. Symptoms of declining black oaks included heavy galling (swollen area of the branch), cankering (vertical seam), and dieback (dead branch tips). (Photo by C. Pike)

Biology and Ecology of Black Oak

Black oak is native to and common across Long Island. It is a deep-rooted species, often found on poor quality soils, such as the drought-prone sandy soils common on much of the Island. Black oak trees can live as long as 250 years; they can attain a height of 60 feet or more and a diameter of 3 feet or more. Black oak reproduction is favored in ecosystems where light is readily available for acorn germination and seedling growth. In forested areas with a dense overstory, natural regeneration is slow, and black

oak seedlings may be outcompeted by other tree species. In residential areas and managed parks, where natural regeneration is frequently suppressed by landowners, planting is normally the only means of regeneration. However, black oaks are not often planted in urban areas; other species such as red oak (*Quercus rubra*) or pin oak (*Q. palustris*) have become much more popular landscape trees.

Parasitic Organisms

Gall Wasps

The gall wasps (non-stinging) found in the swollen twigs of affected black oaks are from the cynipid family of the Hymenoptera. This family of insects generally has a complex life cycle that may include two generations a year—one consisting of all females (asexual) and the other consisting of males and females (sexual). The tiny insects spend most of their lives as larvae, the immature, maggot-like life stage.

The majority (99 percent) of gall wasps identified in this study were *Bassettia ceropteroides* (figure 2). This species has not been thoroughly studied, so little is known about its host preference, life

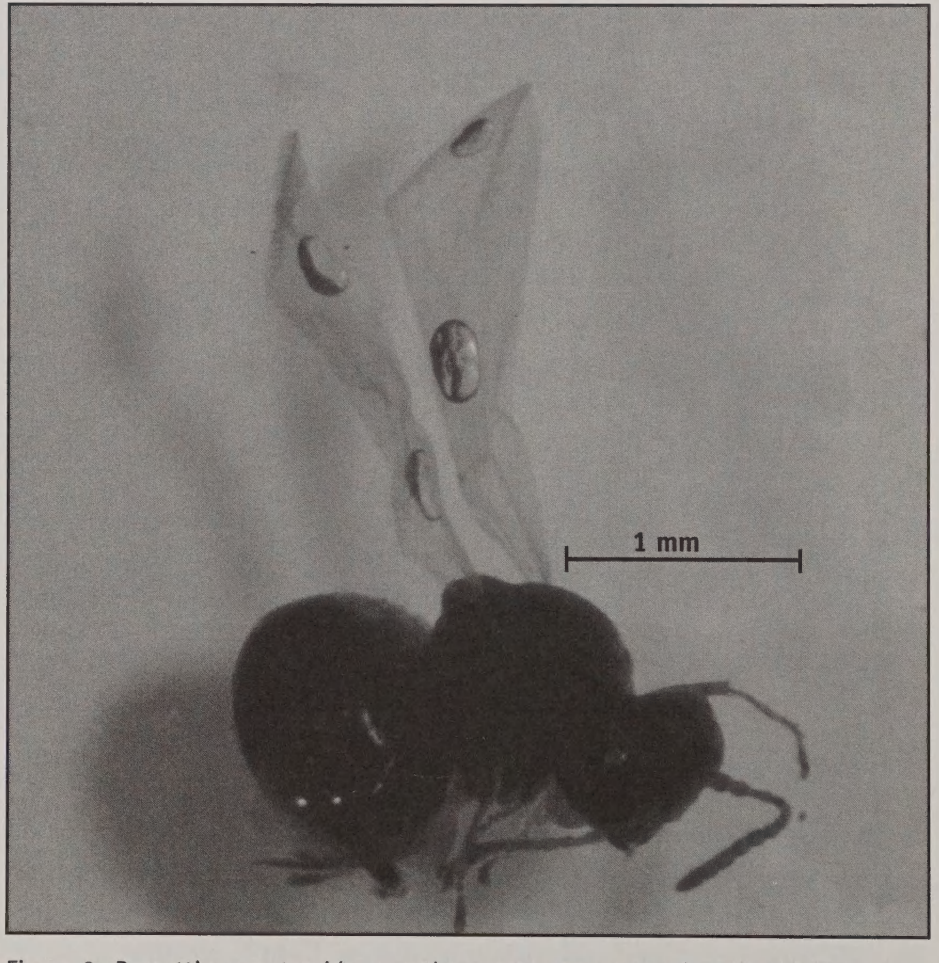

Figure 2. *Bassettia ceropteroides* was the most common species of cynipid wasp removed from black oak twigs. Approximate size is 1/8 inch (3 millimeters). (Photo by C. Pike)

cycle, or feeding habits. Its life cycle appears to occur in the following sequence. In the early spring, possibly before leaves have unfolded completely, a female gall wasp lays eggs on new twig growth. Each larva begins feeding into the twig and eventually forms a fully enclosed gall chamber. Once enclosed, the larva obtains all of its nutrients from the inner surface of the chamber. Within this chamber, the insect passes through to the pupal stage and becomes an adult wasp, a process taking a few weeks. The wasp then chews through the gall chamber and twig, emerging onto the twig surface.

Since only female *B. ceropteroides* have been observed in twig galls, the generation that produces galls is believed to be asexual. The activities of adult females emerging from twigs have not been observed. They may lay eggs on another twig, leaf, or acorn of black oak or another plant species. Here they pass through another life cycle of larva to pupa to adult, emerging as a second generation consisting of males and females. Females then lay eggs on black oak twigs, starting the life cycle over again.

New wood forms around an empty gall after an adult emerges or around a gall containing a larva that dies prematurely. This new growth forms the characteristic swollen twigs associated with this decline (figure 3). Thus, by the time swellings are observed, the insect is no longer active within the gall chamber. These swellings may enlarge and persist for many years as the tree grows.

Gall wasp populations are regulated by the health and vigor of their host trees, natural enemies, and other environmental factors such as weather. When outbreaks do occur, they may persist for a few years or just one season. Afterwards, populations drop to low, endemic levels until the opportunity for another outbreak arises, sometimes after many years.

Gall wasps have not received the notoriety of other forest pests because they generally do not compromise the health of host trees. When large numbers of galls form in twigs on a single tree, however, disruption of water and nutrient flow within the tree's vascular system may produce tip dieback as well as provide entry courts for disease organisms. This is probably the situation that occurred during the decline of black oak on Long Island.

Fungal Canker Disease

Botryosphaeria sp. is a fungal canker disease common on oaks. It generally occurs on the twigs of stressed trees and is most often considered an opportunistic pathogen—one that requires a damaged or stressed tree to successfully establish itself. Trees that are stressed by gall wasps or other insects may be more susceptible to infection

Figure 3. Branches with heavy infestations may appear swollen several years after the wasps completed their life cycles. (Photo by C. Pike)

by *Botrysophaeria*; however, no direct association between *Botryosphaeria* and gall wasps has been made. Other abiotic factors, such as drought stress, are known to increase the susceptibility of oaks to *Botryosphaeria* infection. While this fungus can cause significant damage to stressed trees, it is seldom a problem in healthy trees.

Study Methods

A visual survey of black oak trees was conducted across Long Island's Nassau and Suffolk Counties in 1994 to assess the extent and severity of decline symptoms. The survey included trees in three ecotypes: residential areas (210 trees in 21 plots), managed parks (53 trees in 6 parks), and forested areas (135 trees in 13 areas). Other oak species were examined as well. Trees in residential areas were located along secondary and neighborhood streets and in the yards of private residences. Management of these trees typically included regular watering or fertilization or both during the growing season, as well as potential stress from herbicide use, disturbed and

compacted soil, runoff of pollutants from roadways, and excessive branch trimming. Trees in managed parks were located in picnic areas and campgrounds; they were exposed to pedestrian traffic and possible soil compaction and displacement. In general, these trees were not watered or fertilized, and management was limited to brush or understory removal in some areas. Trees in forested areas were located in county or state parks or preserves and were located at least 100 feet from pedestrian trails. Trees in these areas were generally not actively managed.

For each tree surveyed, the height and diameter were measured and the severity of decline symptoms, including crown dieback by severity class, was estimated. The relative number of branch galls and cankers was estimated from a visual inspection of 10 branches per tree.

Two regions, one on Long Island's north shore (near Riverhead) and one on the south shore (near Heckscher State Park), were studied more intensively in summer 1995. Ninety trees in each region were selected—30 from each of the 3 ecotypes. Within each ecotype, trees were chosen to represent low, moderate, and severe levels of dieback. A 3-foot-long terminal branch sample was taken from each tree and dissected to determine the number of galls, either empty or containing a dead wasp, within each year of twig growth. These counts were used to estimate the gall wasp population from 1990 to 1995. To determine the growth rate of trees over time, an increment core containing a cross section of tree rings was taken from the main stem of each tree at a point about 4.5 feet above the ground. The width of each growth ring was measured and basal area growth was estimated for each year. Tree age was also estimated from counts of the growth rings.

Results and Discussion

The decline syndrome was evident throughout the two counties surveyed, where black oaks are more common than in the highly urban areas in western Long Island (Queens and Kings [Brooklyn] Counties). Symptoms were found in residential areas, managed parks, and forested areas, but were not uniformly severe across the Island, suggesting that certain microsite characteristics contributed to the decline. The presence of declining trees in all three ecotypes also suggests that direct human impacts were unlikely to have influenced decline severity. Among the residential areas surveyed, trees with severe crown dieback were generally clustered along the south shore of Long Island. Crown dieback was generally moderate along the north shore and low throughout the interior and eastern south fork (figure 4). These zones of low, moderate, and severe

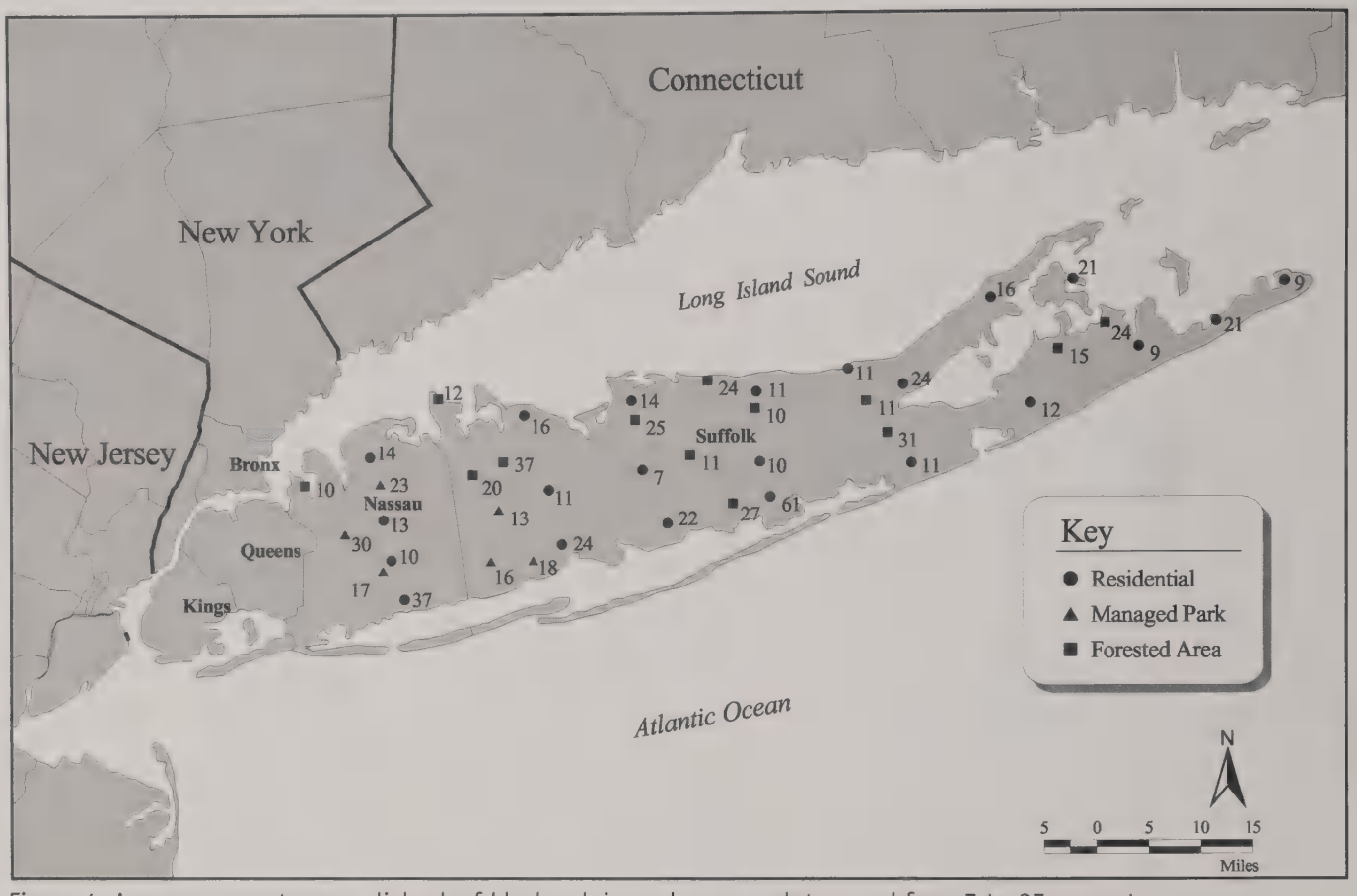

Figure 4. Average percent crown dieback of black oak in each survey plot ranged from 7 to 37 percent.

dieback correlate with the major soil associations of Long Island,areas but no cause-and-effect relationship between particular soil properties and the decline syndrome can be assumed.

The decline syndrome was confined to black oak trees. While galls, cankers, and dieback were observed on other species of oaks, the combination of these symptoms was found only on black oaks. All size and age classes of black oak were affected, but no significant correlations between them and decline severity were found. The extent of the decline varied greatly within a given area—some oaks were severely affected (figure 5), while others, sometimes directly adjacent to declining trees, showed few or no symptoms (figure 6). These findings suggest that susceptibility to decline is governed by a combination of individual tree site factors and genetic predisposition.

Analysis of growth rates from increment cores indicated that trees having severe dieback in 1995 also had slower growth many years prior to the decline than did trees with less dieback (figure 7). Growth rates of severely affected trees in residential areas were noticeably slower from 1989 to 1995. These trees may have been predisposed long before the emergence of this syndrome. It is unlikely that gall wasps targeted these trees, but weakened trees were

Figure 5. Extensive crown dieback indicated advanced black oak decline. (Photo by C. Pike)

more likely to suffer as a result of gall wasp infestation. Incremental growth of trees in residential areas and managed parks was two times greater than of trees in forested areas, on average. This difference reflects, at least in part, the greater density of trees in forested areas, as well as other management and site factors. In general, decline symptoms were less severe in forested areas than in more developed areas.

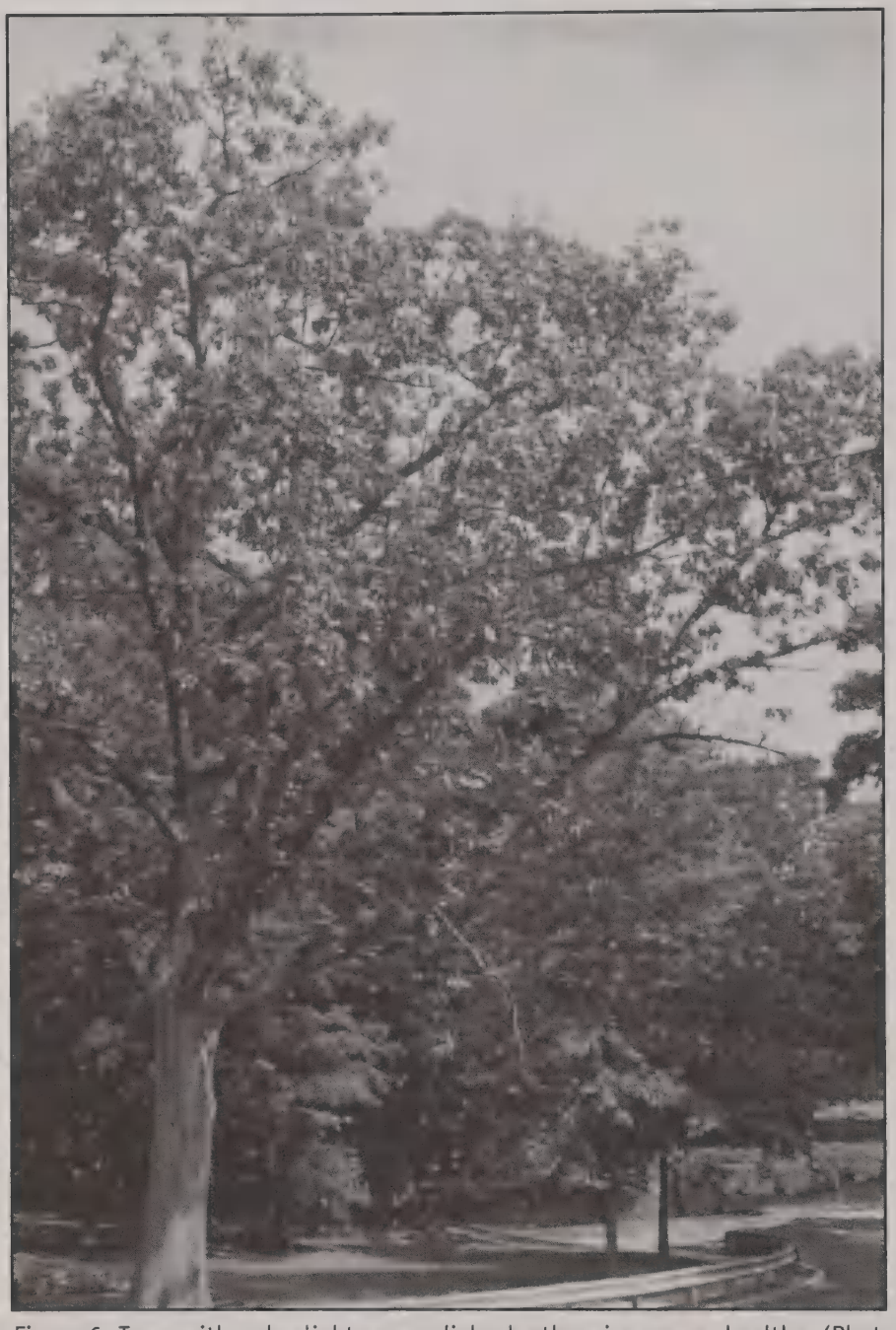

Figure 6. Trees with only slight crown dieback otherwise appear healthy. (Photo by C. Pike)

Increment cores also revealed reduced incremental growth due to widespread gypsy moth defoliation on black oak in 1980–1981 and droughty conditions during the late 1980's (figure 7). Both of these factors, as well as several severe windstorms during the 1980's and early 1990's, may have contributed to the development of the decline.

Gall wasp populations reached higher levels in residential areas than in forested areas, as determined by twig dissections (figure 8). It was not possible to accurately discern wasp chambers in twigs predating 1990. It appears that by 1990 the gall wasp population had reached

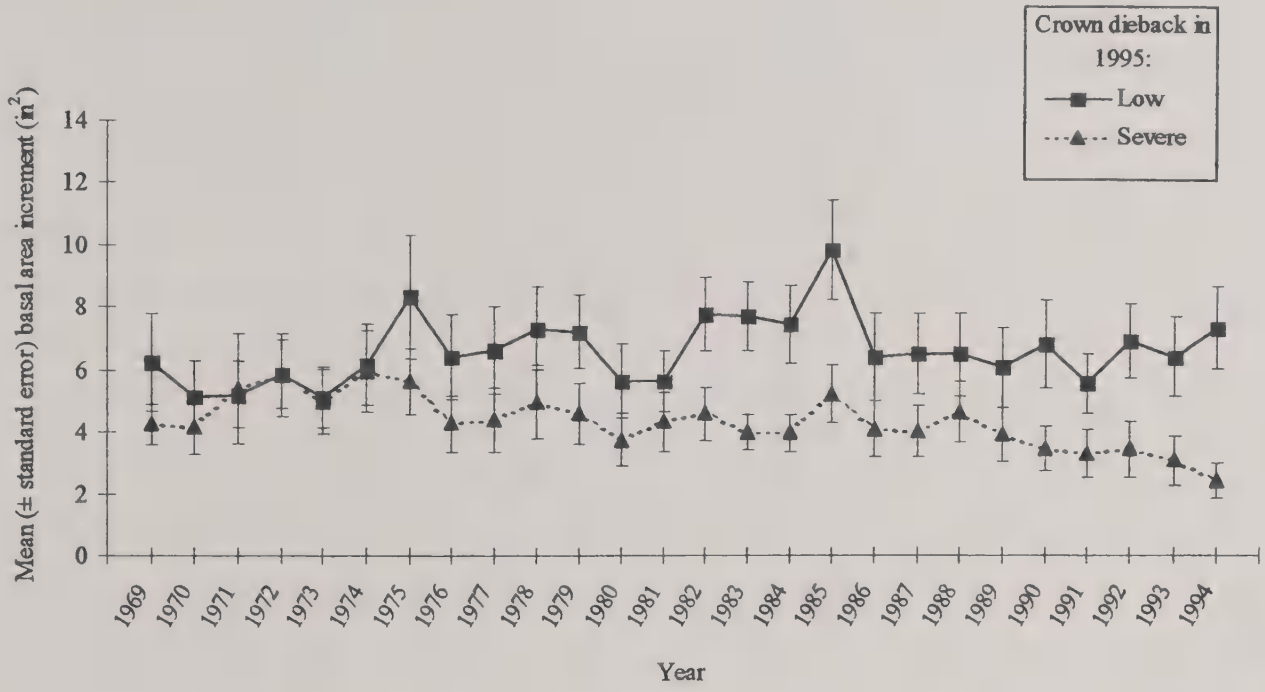

Figure 7. Mean basal area (radial) growth (from increment core analysis) of black oak trees in residential areas of Long Island, from those recorded as having low or severe crown dieback in 1995. Average radial growth gradually decreased in trees affected by the black oak decline syndrome and gradually increased in trees unaffected by the syndrome from 1988 to 1994. For many years declining trees grew more slowly, on average, than trees that appeared healthy.

its peak and was declining in forested areas, whereas it continued to increase in residential areas until 1992. The wasp's magnitude and rate of population change was greater in residential areas than in forested areas, at least during 1990–1993, and wasp populations returned to endemic levels earlier in forested areas than in residential areas. Additionally, there was little difference in wasp populations between trees having low and severe crown dieback in 1991–1993 in forested areas, whereas in residential areas this difference was substantial. Finally, the data indicate that by the time the black oak decline was studied in 1994–1995, wasp populations had already begun to decrease in residential areas. By 1996 it was evident across Long Island that the decline had subsided and trees were recovering. There had been considerable black oak mortality reported during the early 1990's; however, in many cases trees were removed for aesthetic and safety reasons prior to actual mortality, and a direct link between the decline and tree death was never established.

Studies of other gall wasp populations have observed similar patterns in residential areas compared with forested areas, leading researchers to postulate the following:

1. Wasps are isolated from natural enemies for longer periods of time in residential areas than in forested areas. Host trees in isolated urban pockets may provide gall wasps an escape from parasitizing insects or predators.

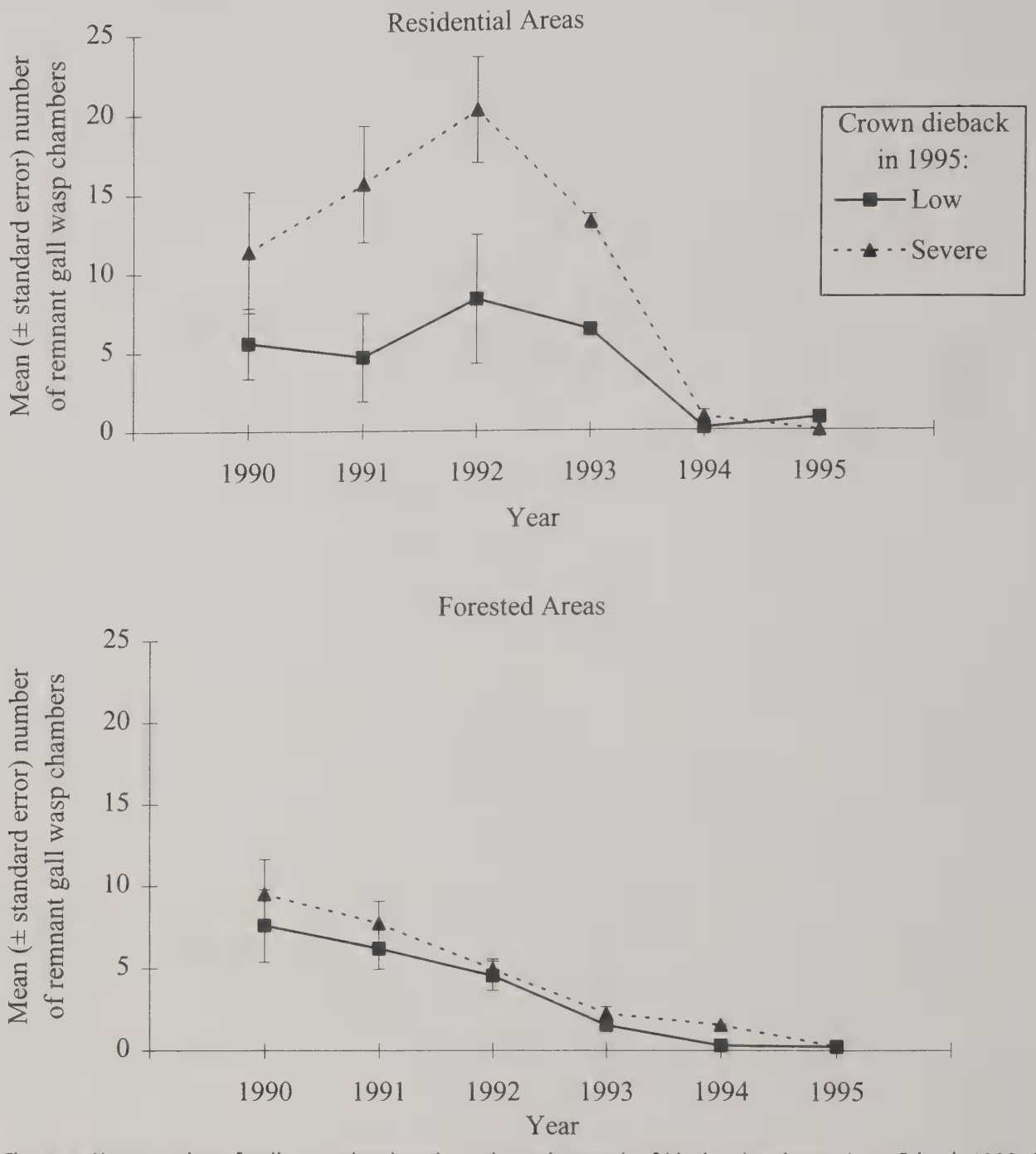

Figure 8. Mean number of gall wasp chambers in each year's growth of black oak twigs on Long Island, 1990–1995, in residential and forested areas, from trees recorded as having low or severe crown dieback in 1995. The average number of gall wasps excised from each year's growth decreased gradually in forested areas (lower graph) but sharply increased then decreased in residential areas (upper graph) from 1990 to 1995.

2. Gall wasps are more successful in residential areas because host trees are more vigorous, which benefits the wasps. It should be noted, however, that in this study, vigorous trees suffered less dieback despite having high wasp populations.
3. Estimates of decline in forested areas may be conservative. It was difficult to assess the extent of symptoms in many forests where black oak is not a common species.

Summary of the Decline Syndrome

In this survey, only mature black oaks from 27 to 133 years of age were studied. Trees throughout this age range were susceptible to the decline. It is generally assumed that trees in the middle of this age bracket can be the most sensitive to stress because they lack the resilience of younger trees and have not "stood the test of time" as older trees have. Age was not, however, a reliable indicator of tree susceptibility in this study. It does appear that trees in residential areas and managed parks were more susceptible than those in forested areas.

The combined effects of site factors, gypsy moth defoliation (early 1980's), and severe drought (late 1980's) probably reduced the vigor of some trees, leading to dieback after heavy gall wasp attack and associated *Botryosphaeria* infection in the mid-1990's. Although most trees surveyed were infested by gall wasps, trees with reduced growth rates before gall wasp attack showed the most pronounced symptoms of dieback and decline after the gall wasp populations had dissipated.

It is difficult to determine how the gall wasp population emerged and spread, or how the decline developed. Questions remain—for example, did the wasp originate from a single locale on the Island, or did a region-wide occurrence trigger the emergence of many insects simultaneously? Gall wasps are weak fliers and are not know to travel great distances. Thus, it is not likely that populations emerged and spread from a single locale. Instead, outbreaks probably originated from local populations triggered by a set of environmental conditions common to the region. Surveys did not find contiguous areas with swollen twigs and crown dieback in New York City, coastal or northeastern areas of New Jersey, or coastal Connecticut. Therefore, some condition unique to central and eastern Long Island is likely responsible for prompting the gall wasp outbreak. Trees in this region that were predisposed revealed the most visible decline symptoms (dieback, galls, and cankers) after infestation by gall wasps.

During the 1960's similar decline symptoms, including twig galls and crown dieback, were anecdotally reported on a few Long Island trees. Previous research (see Related References on page 13) indicates that gall wasp outbreaks in many locales worldwide occur sporadically or cyclically, with populations and damage rising and falling in tune with some set of natural factors. This was probably the case on Long Island for the decline syndrome of the 1990's. All evidence indicates that the syndrome was no longer prevalent on Long Island as of summer 1996, with any remaining occurrences confined to small, localized pockets. No new problems with black oak have been reported since 1996. The health of the remaining

population of black oak across the island is probably good, considering that the weakest trees were most affected by the syndrome and many were removed by subsequent cutting. Subtle changes in species composition in all ecotypes where black oaks were impacted may have occurred.

Based on these findings, Long Island's black oak decline syndrome appeared in the late 1980's and had diminished across the Island by 1996. This cycle is not unexpected. Additional cycles of black oak decline associated with gall wasps may emerge in the future and follow similar patterns of damage and recovery. There is no evidence to suggest or identify any particular human-caused factor leading to this syndrome.

Management Recommendations

Arborists and others involved in the care and management of trees on Long Island responded in various ways to the syndrome and to requests for help from their clients—private and public property owners and managers. Practitioners tried intensive irrigation and fertilization, insecticidal sprays and injections, soil aeration, and removal of the galls by pruning. In some cases trees were cut and removed either because large dead limbs appeared to pose a threat to public safety and property or because the trees had become unsightly or died. While some operators reported occasional success at improving tree health, no documented evidence exists to support the use of these actions to control or manage this syndrome or the associated insects and disease.

As often as not, trees recovered without treatment as the syndrome diminished naturally. Healthy trees with vigorous growth were less susceptible to decline; therefore, maintaining tree vigor may be the best management strategy. Slow growth of trees before the onset of dieback appears to be the best indicator of future decline severity.

Galling insects are generally well protected from insecticidal sprays and tree injections. In fact, the gall itself consists of modified tree cells that protect the insect from toxic plant chemicals as well as from the external environment. Aerial application of insecticides might be effective if extraordinarily well timed with the emergence and flight of adult wasps. Research at the University of Maryland-College Park found that careful monitoring could identify the time of adult wasp flight in the spring. A spray protocol was not developed from the data, however, because the disappearance of the syndrome and gall wasp populations by 1996 precluded such studies.

Integrated management of this decline syndrome is best accomplished through the maintenance of tree health and vigor, and

the removal of affected trees when they pose a threat to human safety or property. In parks and residential areas, planting diverse tree species will avoid wholesale loss of tree cover when the next decline or pest episode develops.

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